Perspective

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Geological Society of London Scientific Statement: what the geological record tells us about our present and future climate

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Executive Statement

Geology is the science of how the Earth functions and has evolved and, as such, it can contribute to our understanding of the climate system and how it responds to the addition of carbon dioxide (CO_2) to the atmosphere and oceans. Observations from the geological record show that atmospheric CO_2 concentrations are now at their highest levels in at least the past 3 million years. Furthermore, the current speed of human-induced CO_2 change and warming is nearly without precedent in the entire geological record, with the only known exception being the instantaneous, meteorite-induced event that caused the extinction of non-bird-like dinosaurs 66 million years ago. In short, whilst atmospheric CO_2 concentrations have varied dramatically during the geological past due to natural processes, and have often been higher than today, the current rate of CO_2 (and therefore temperature) change is unprecedented in almost the entire geological past.

The geological record shows that changes in temperature and greenhouse gas concentrations have direct impacts on sea-level, the hydrological cycle, marine and terrestrial ecosystems, and the acidification and oxygen depletion of the oceans. Important climate phenomena, such as the El Niño–Southern Oscillation (ENSO) and the monsoons, which today affect the socio-economic stability and food and water security of billions of people, have varied markedly with past changes in climate.

Climate reconstructions from around the globe show that climate change is not globally uniform, but tends to exhibit a consistent pattern, with changes at the poles larger than elsewhere. This polar amplification is seen in ancient warmer-than-modern time intervals like the Eocene epoch, about 50 million years ago and, more recently, in the Pliocene, about 3 million years ago. The warmest intervals of the Pliocene saw the disappearance of summer sea ice from the Arctic. The loss of ice cover during the Pliocene was one of the many rapid climate changes observed in the record, which are often called climate tipping points. The geological record can be used to calculate a quantity called Equilibrium Climate Sensitivity, which is the amount of warming caused by a doubling of atmospheric CO_2, after various processes in the climate system have reached equilibrium. Recent estimates suggest that global mean climate warms between 2.6 and 3.9°C per doubling of CO_2 once all slow Earth system processes have reached equilibrium.

The geological record provides powerful evidence that atmospheric CO_2 concentrations drive climate change, and supports multiple lines of evidence that greenhouse gases emitted by human activities are altering the Earth's climate. Moreover, the amount of anthropogenic greenhouse gases already in the atmosphere means that Earth is committed to a certain degree of warming. As the Earth's climate changes due to the burning of fossil fuels and changes in land-use, the planet we live on will experience further changes that will have increasingly drastic effects on human societies. An assessment of past climate changes helps to inform policy decisions regarding future climate change. Earth scientists will also have an important role to play in the delivery of any policies aimed at limiting future climate change.